ON DENTAL INCRUSTATIONS AND THE SO-CALLED "GOLD-PLATING" OF SHEEP'S TEETH.

By Thos. Steel.

For many years past there have appeared from time to time, in newspapers and magazines published all over the world, statements as to the occurrence of a metallic incrustation on the teeth of sheep. The incrustation in question is usually found more or less thickly coating the sides of the molar teeth, and, being frequently of a shining, yellowish, metallic appearance, has been popularly attributed to gold supposed to have been derived from particles of that metal scattered about the pastures. So deeply-rooted is the popular belief that the incrustation consists of gold, my friend, Mr. J. H. Campbell, informs me that persons have brought jaws of sheep to the Royal Mint, Sydney, with a view to selling them for the supposed adherent gold. Quite recently, it was most confidently asserted by correspondents in *Nature** that the incrustation consisted of iron pyrites, and various fantastic theories were put forward to account for the presence of this substance in such a situation.

In 1905 Professor Liversidge exhibited at a meeting of the Royal Society of New South Wales† part of a sheep's jaw, heavily coated with yellow metallic-looking deposit, and read a descriptive note with a qualitative analysis, clearly showing the true nature of the substance to be a deposit derived from the saliva, and that the metallic appearance was due to the refraction of light by the overlapping edges of the thin lamellae of the deposit. Again, in July, 1905, the same gentleman exhibited and explained the deposit at a meeting of the Sydney section of the Society of Chemical Industry. Similar specimens were exhibited by Horan to the New South Wales Naturalists' Club in 1913.‡

As will be shown in this paper, the presence of such deposits is by no means confined to the teeth of sheep, but is a common occurrence on those of a very large variety of animals, including man. It is, in fact, a dental calculus analogous to those occurring in the urinary tract.

The earliest account of the true nature of dental incrustations with which I have met, occurs in the Annals of Philosophy.§ In the course of a series of articles entitled "General Views of the Composition of Animal Fluids," Berzelius gives a correct explanation of the nature of the deposit from human teeth, and his analysis of a specimen, which will be quoted further on.

In 1834, Dr. G. Bennett‖ records having observed a layer of "metallic substance" incrusting the teeth of kangaroos, and correctly diagnosed it as "tartar"

*Nature, xcix., 1917, pp.264, 284, 290, 306; c., 1917, p.106.

†Journ. Roy. Soc. N.S.Wales, xxxix., 1905, p.33; also Chem. News, xcii., 1905, p.115; Jour. Soc. Chem. Ind., xxiv., 1905, p.1039.

‡Australian Naturalist, ii., 1913, pp.174, 187.

§Thomson's Ann. Phil., ii., 1814, p.380.

‖Wanderings in New South Wales, i., 1834, p.294.

precipitated from the saliva. He mentions its occurrence in the ox and sheep, and remarks that on account of its yellow colour it is frequently mistaken for gold. He quotes the analysis by Berzelius mentioned above.

In a paper published in 1879, "On Macrodontism," N. de Miklouho-Maclay‡ described and figured the huge projecting teeth which he observed in natives of the Tani or Admiralty Islands, and refers to a sketch in *Nature** which he describes, however, as a caricature. In a subsequent paper† he explains that further investigation had shown that he was mistaken in supposing that the projections were due to dental malformation, but that they really consisted of an enormous deposit of "tartar," probably largely due to the habit of these people of chewing betel nut and lime. The deposit could be detached, leaving the teeth quite normal. The late Mr. P. R. Pedley, surgeon-dentist, who examined the deposit, identified it as dental tartar. Unfortunately there is no record of a chemical examination having been made. Miklouho-Maclay proposed the term "odontolithiasis" for this condition.

From the stocks of bones passing through a large bone charcoal factory in Sydney, I have been able to examine the teeth of numerous sheep and also those of oxen, horses, pigs, etc., and to secure ample material for a complete chemical analysis of the deposit from the teeth of sheep and oxen. From other sources I have obtained sufficient for quantitative analysis from the teeth of a number of animals, including man. By the courtesy of the late Mr. R. Etheridge, specimens from the teeth of animals in the Australian Museum, Sydney, were secured, sufficient in a few cases for full analysis, and in a considerable number of others for qualitative determination. Mr. H. A. Longman, F.L.S., Director of the Queensland Museum, kindly allowed me material from the skeleton of a camel. In all such cases care was taken to insure that the deposit obtained was pure and not contaminated with lime which may have been used in the preparation of skeletons.

Very commonly the taxidermists appear to have carefully cleaned the teeth. My kinsman, Mr. A. Ross Brown, B.D.Sc., L.D.S., of Windsor, Melbourne, and my friend, Mr. J. Darton, surgeon dentist, Petersham, furnished me with an ample supply from human teeth, secured in the course of their professional practice in the operation of "scaling." Mr. Charles Hedley, Acting Curator of the Australian Museum, kindly gave me facilities, with the aid of Messrs. Thorpe and Troughton, to examine the large collection of skulls in the Museum. To Professor J. Douglas Stewart, of the Veterinary School, Sydney University, I am indebted for explaining to me details regarding the structure of teeth and giving me other information. To all of these gentlemen I desire to tender my best thanks. Further material was obtained from specimens in my own collection and passing through my hands. In addition to examining the dental deposit, I have, in the cases of the ox and camel, made an analysis of the cement or cementum layer (*crusta petrosa*). In these animals this layer is strongly developed, extending well up on the exposed part of the tooth, and can be readily separated. The incrustation could, in most cases, be easily flaked off from either the cement or the enamel and the surface beneath was always quite sound.

The figures following give the results. The samples were ground, and air-dried at ordinary temperature.

‡Proc. Linn. Soc. N.S. Wales, iii., 1879, p.169.

*Nature, xvi., 1877, p.251.

†Proc. Linn. Soc. N.S. Wales, x., 1886, p.682.

ANALYSES OF DENTAL INCRUSTATIONS.

	Man	Sheep	Ox	Camel	Dromedary	Rhinoceros	Babirussa	Cement layer (*Crusta petrosa*) Ox	Cement layer (*Crusta petrosa*) Camel
Lime (C_aO)	40·75	28·00	29·38	37·75	37·00	46·13	47·50	35·69	36·21
Magnesia (Mg O)	0·18	4·19	3·69	0·27	0·18	0·56	0.68	1·12	0·98
Phosphoric oxide (P_2O_5)	34·73	26·55	28·17	29.33	29·48	7·95	7·14	26·68	26·88
Carbon dioxide (CO_2)	1·32	1·45	1·10	2·70	2.88	22·65)	41·63	2·90	1·80
Organic matter*	17·23	24·65	23·90	16·20	16·82	17·48)		23·54	24·74
Water at 110° C.	5·38	11·03	10·30	11·65	10·40	3·85	2·63	9·35	8·66
Sand	0·10	2·30	2·00	0·60	0·30	0·55	0·39	nil	nil
Undetermined and loss	0·31	1·83	1·46	1·50	2·94	0·83	0·03	0·72	0·73
	100·00	100·00	100·00	10·000	100·00	100·00	100·00	100·00	100·00
*Containing nitrogen	1·20	1·48				0·74			
Sp. Gr.	2·317	2·025						2·112	

Miklouho-Maclay mentions that specimens of teeth similarly incrusted to those which he describes were forwarded by F. A. de Roepstorff from the Nicobar Islands to Professor Virchow, Berlin.† The deposit from these was analysed by Salkowski, and the results published by Virchow, the following being the figures:—

Water	5.95
Organic matter	9.10
Silica and iron oxide	.87
Iron phosphate	2.26
Lime	45.24
Magnesia	.68
Phosphoric oxide	30.73
Carbon dioxide	4.87
	99.70

This shows more lime and carbon dioxide and considerably less organic matter than I found in the normal incrustation from human teeth. Probably this is a result of the addition of carbonate of lime from the lime-betelnut habit, but the high phosphoric acid shows that essentially the deposit has been derived from the saliva. The presence of so much iron phosphate is peculiar, and I am unable to explain it. I found no appreciable iron in any of my samples.

The analysis by Berzelius mentioned above, is thus stated:—

Earthy phosphates	79.0
Mucus	12.5
Peculiar salivary matter	1.0
Animal matter soluble in muriatic acid	7.5
	100

There is no mention of water. It is probable that Berzelius merely ignited and took the ash as "earthy phosphates," and the organic substances include water. For a rough comparison it will suffice to consider the "phosphates" as being tribasic phosphate of lime and to lump together the organic substances. This would give:—

†Verh. Berlin. Ges. Anthrop., June, 1881, p.219.

Lime	43.
Phosphoric oxide	36.
Organic matter and water	21.
	100.

These figures agree very well with my analysis of the human product. In my examination I found the total loss on ignition, including water and carbon dioxide, was 24 % and the ash 76 %.

In my analysis, in every case the sand was in the form of mechanically embedded grains. It will be noticed that the incrustations from the Rhinoceros and Babirussa (a pig-like animal from N. Celebes) differ from the others in containing but little phosphoric acid and a considerable proportion of calcic carbonate. In both of these the scale, when detached, was in appearance much like that from the sheep and ox, being in clean shining flakes. In man it is chalky-looking and has not got the metallic, or more commonly, nacreous look of that from the sheep. The similarity in composition between most of the incrustations and that of the cement layers of ox and camel is striking. Ordinary mammalian bone has also a very similar composition.*

In making the analyses, care was taken in separating lime and magnesia, by double precipitation of the lime in the cold to avoid co-precipitation of magnesia. The proportions of lime and phosphoric acid present are such as to indicate that the phosphate of lime does not exist entirely as the tribasic ($Ca_3 P_2 O_8$), but that a variable amount of the tetrabasic ($Ca_4 P_2 O_9$) is also present. I have found this to be a usual condition in many natural phosphates such as those from Ocean Island.

Bearing in mind the analogy between these dental salivary incrustations and urinary calculi, a careful examination was made of those from man, sheep and ox for oxalic and uric acids, but with entirely negative results.

I have examined the deposit from a large variety of animals in addition to those already mentioned, using micro-chemical methods when the amount available was minute, and in every case have found it to be of substantially the same nature. The quantity present varies from a mere trace of brown film, to a heavy incrustation packed round the crowns of the teeth and forming a continuous coating along the sides as much as a quarter of an inch in thickness. It is heaviest in herbivorous animals and in man. The teeth of the carnivorae and rodents are usually very clean; this is well seen in dogs, cats, mice and rats, though all of these, particularly when old, and also rabbits, frequently have a thin brown film even on the incisors. Some individuals are more predisposed to dental incrustation than others. This is well-known in man, and I have noticed it in sheep and other animals. The teeth of snakes, lizards and fish in so far as I have noticed, appear to be always quite free from deposit.

I do not think that the nature of the pasture, as has sometimes been asserted, has anything particular to do with the abundance or otherwise of the deposit on sheep's teeth, but that it is purely a physiological idiosynerasy. Sheep and oxen very commonly have the teeth coated with a uniform, thin, dead black film, but this does not differ in composition from the thicker deposit. The common pig has very clean teeth. I have examined many hundreds of pigs' jaws, and have never noticed more than traces of a brown film.

*Watt's Dict. Chem., vi., 1879, 1st. Supp., 357.

Extended observation has satisfied me that the incrustation, in greater or less degree, is common to all mammals, and also to a number of other animals, in every case being of the same general character. I have found it, for instance, in the crocodile (*C. porosus*) Queensland, killer whales (*Orca gladiator*), and in one individual or another of practically every mammalian species examined. It will suffice to give the names of a few as indicating the scope of the investigation: Tapir, eland, American bison, hippopotamus, various bears, dog, cat, rat, mouse. Examination of the skulls of marsupials in the Australian Museum collection and elsewhere disclosed numerous examples: *Macropus major*, quite as heavy as that of the sheep, *M. giganteus*, *M. rufus*, *Phascolarctus cinereus*, *Phascolomys mitchelli*, *Dasyure*, and many others. The original observations of Dr. Bennett are thus completely confirmed. Fossil marsupial teeth from Wellington Caves, New South Wales, in the Australian Museum, still have adhering brown patches which I take to be the same deposit. Wherever the teeth of animals were noticed to have a yellow or brownish tint as in aged rats, minute examination showed this to be due to the same cause.

In response to queries from me, Mr. Brown has supplied me with the following very interesting notes:—"Tartar forms on artificial *plates*, especially lower plates, quite as readily as on the natural teeth; it is an everyday occurrence to see that. It is deposited along the lower portion of the lingual side of the *plate*, and dentists are continually asked by patients what it is and how to remove it. I do not remember seeing teeth forming part of a bridge with tartar deposited on them, but frequently find that the gum having slightly receded after the bridge has been fixed, a slight deposit is to be seen round the gingival margin of the natural roots to which the bridge is attached. Porcelain crowns (pivots) and gold crowns or caps remain free from deposit. I once had to remove from an elderly woman's mouth a little lower plate having three teeth on it, and there was such an accumulation of tartar all about the whole structure and the remaining teeth that two of the latter were extracted in the removal of the plate; these, however, were loose from pyorrhoea. In this case the tartar had certainly encroached to some extent on the artificial teeth. The patient informed me that she had not removed the denture since the dentist put it in place many years before. This case was an exceptional one, and as I have mentioned, I do not remember seeing deposit on artificial teeth at any other time."

I think it is probable that the nature of the surface of porcelain teeth and gold crowns inhibits the adhesion of deposit. In the case of the urinary tract, it is well known that any solid foreign body, such as a piece of broken catheter, soon becomes coated with phosphate, and that a little blood clot or even bacteria may form the nucleus of a urinary calculus.